Name Date

HANDS-ON LAB

Friction: Testing Materials

Almost every device contains surfaces that rub against one another. Some devices require high friction surfaces because their function involves maximizing contact forces. These devices grip, hold, push, pull, or rotate other objects. Other devices might require low friction surfaces, which minimize contact forces, because their function is to slide easily over another surface or to travel rapidly through a fluid environment. A materials scientist will identify the properties and behaviors of different materials through investigation.

In this lab, you will play the role of a materials scientist. To quantify the friction of the surfaces that are in contact, material scientists use the coefficient of friction. The coefficient of friction is the ratio of the frictional force between two surfaces and the normal force of one of those surfaces on the other. You will test different pairs of surfaces to determine the coefficients of static and kinetic friction for each one and then rank them accordingly. After identifying the pair of surfaces that has the lowest coefficient of kinetic friction, you will propose possible uses for that surface within a designed device.

RESEARCH QUESTION Which surface paired with the standard material offers the lowest coefficient of static friction? Does this pair of materials also have the lowest coefficient of kinetic friction?

MATERIALS

- safety goggles
- balance
- cardboard
- cellophane
- corkboard
- felt
- force meters (2)
- masking tape
- masses (1 set)
- paper towels or wipes
- sandpaper, large sheets
- unidentified materials (1 box)
- vinyl or linoleum flooring
- wood friction block with hook
- yoga mat, cut into large squares

MAKE A CLAIM

1. When a standard material is pulled across it, which surface do you think will have the lowest coefficient of kinetic friction? Why? Will this surface also offer the lowest coefficient of static friction with the standard? Why or why not?

2. How do you think the coefficients of kinetic friction and static friction can help you predict how a surface will behave when it comes in contact with another surface? What uses do you think pairs of materials with either high or low coefficients of kinetic friction have?

SAFETY INFORMATION

- Wear safety goggles during the setup, hands-on, and takedown segments of the activity.
- Secure loose clothing, wear closed-toe shoes, and tie back long hair to prevent their getting caught in moving or rotating parts.
- Perform this experiment in a clear area. Falling or dropped masses can cause serious injury.
- Immediately pick up any items dropped on the floor so they do not become a slip/fall hazard.
- Wash your hands with soap and water immediately after completing this activity.

PLAN THE INVESTIGATION

1. As you plan the procedure, keep in the mind the following:

- The coefficient of friction describes a relationship between two surfaces. You will need to use as a standard surface of known weight (F_g) to test against all surface types. The wood block will be the standard. You should record a complete description of how the wood block interacts with each surface tested. If there is time, perform all surface tests against a second material.
- Force meters must be used in a consistent manner or you will introduce both random and systematic error into your experiment. Kinetic friction must be measured when the surface is moving with constant velocity. Think about how you will attach the spring scale securely to the standard as well as how you will use the force meter to measure both static friction and kinetic friction in a consistent way in each trial.
- Decide how many trials you should conduct for each surface in order to obtain valid measurements. You need to measure or calculate coefficients of friction to two significant digits.
- You will need to plan a method to recording your measurements and calculations.

2. Write down the method you will use to test the surfaces and to determine the coefficients of static and kinetic friction between each surface and the wood block. Construct a data table to record your observations, measurements, and calculations for each trial. Then have your teacher approve your plan.

COLLECT DATA

Conduct your experiment. Make sure that you record measurements carefully so that you can identify and reconcile any discrepancies between the coefficients of friction that you calculate and those calculated by your classmates as they test the same surface combinations.

CALCULATE

Average the force measurements recorded from multiple trials, then use the equations provided by your teacher to calculate the coefficient of static friction (μ_s) and the coefficient of kinetic friction (μ_k) for each surface.

ANALYZE

Consider the coefficients of friction between each surface and the wood block. Are the coefficients of static and kinetic friction for a pair of surfaces the same? Rank the coefficients of static friction from the lowest to highest value. Next, rank the coefficients of kinetic friction from the lowest to highest value. Are the rankings the same? If not, what might explain the differences?

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CONSTRUCT AN EXPLANATION

1. **Patterns** What patterns do you observe in the coefficients of static and kinetic friction as you compare them to the characteristics of different surfaces?

2. **Use Computational Thinking** Jupiter is many times more massive than Earth. If you repeated this experiment on Jupiter, do you think the coefficients of static and kinetic friction would be the same as, lower than, or higher than what you measured on Earth? Explain your reasoning.

DRAW CONCLUSIONS

Write a conclusion that addresses each of the points below.

Claim How do the coefficients of static and kinetic friction help you predict how a surface will behave when it comes in contact with another surface?

Evidence What evidence from your investigation supports your claims?

Reasoning Explain how the evidence you provide supports your claim. Describe in detail the connections you make between the evidence you cited and the argument you are making.

EXTEND

Choose a mechanical device that people might use every day, such as a hand-held can opener. Where is friction needed in the device? Where is friction minimized in the device? Compare the surfaces used at these locations with the surfaces tested in the investigation. Explain how your investigation might help you predict the coefficients of friction for the pairs of surfaces used in the device.